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GIFFORD PINCHOT, Forester

THE SEASONING AND PRESERVATIVE TREATMENT OF ARBORVITÆ POLES.

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THE SEASONING AND PRESERVATIVE TREATMENT OF ARBORVITÆ POLES.

INTRODUCTION.

Arborvitæ, on account of its strength, lightness, durability, and form, is the most desirable telephone and telegraph pole timber. Its use has been extended to regions remote from the base of supply and rapid depletion has resulted. This is indicated by a rise in price for 30-foot poles of 156 per cent in the last eleven years. Arborvitæ is extremely slow in growth, and under natural conditions does not form a close stand. Hence a supply large enough to meet an annual consumption as large as the present one can not be expected from future growth. As a consequence it becomes necessary to investigate carefully every possible method of handling the poles to increase their length of service.

In experimental work along these lines, which the Forest Service has been conducting in cooperation with the American Telephone and Telegraph Company, 50 green 30-foot arborvitæ poles were cut every month for nine months. The first 50 were cut April 22, 1905, and 50 monthly thereafter until December, 1905, inclusive. Subsequently 4 poles were broken or lost, leaving 446. The poles were cut near Metropolitan, Mich., and yarded at Escanaba, Mich.

All poles were peeled immediately after being cut and were then skidded in the woods in single tiers about 2 feet above the ground. Each pole was numbered, its weight taken, and its circumference at 6 feet and at 30 feet from the butt recorded.

The poles were weighed by means of a "steelyard scale" attached to the end of a lever 12½ feet long working between 4 legs 7½ feet long. The remainder of the apparatus consisted of a chain about 8 feet long, which was hung by the middle to the lower hook of the scale, and to each end of which was attached a pair of skidding tongs. (Fig. 1). When a pole was to be weighed, the lever was raised as high as possible and the skidding hooks set into the pole on either side of the balancing point. The lever was then brought down and the pole raised from the skids. The poles were weighed at intervals thereafter.

After a long period of seasoning the circumferences were again measured at 6 feet and at 30 feet from the butt in order to determine the amount of shrinkage. A series of circumference measurements was made also at the butt and at successive 5-foot points to determine

the volume, weight per cubic foot, and taper of an average pole. Note was made of checking during seasoning.

Upon completion of the seasoning experiment different methods of preservative treatment of the pole butts were tried, consisting of brush treatments with carbolineum and creosote and open-tank treatments with creosote. Records were kept of duration of treatment, temperature of oil, and depth of penetration.

FIG. 1.—Telephone poles—skidding and weighing.

SEASONING.[a]

FACTORS INFLUENCING SEASONING.

While the poles lay on the skids in the woods, the wind, a potent factor in seasoning, could not get free access to them on account of the surrounding stand of timber. The sun, another valuable seasoning agency, reached them for only a short time each day. The trees grew on swampy ground and the soft, spongy soil under the skids was constantly full of moisture, which kept the air under and around them more or less charged. Rain and snow, which fell plentifully during the progress of the experiment, were evaporated slowly. Snow covered the poles from about the first of November until the first of April. However, in February, 1906, all the poles were removed to the Escanaba yard, where conditions were much more favorable. The soil is pure sand. The ground cover consisted of scant grass and occasional huckleberry bushes, nowhere thick enough to prevent free circulation around and under the skids. The poles

[a] Forest Circular 103, "Seasoning of Telephone and Telegraph Poles," deals with this subject in detail.

were exposed to the sun during the entire day, and rain and snow, followed by sun or dry winds, soon evaporated. Seasoning continued until November, 1906. The last weights in the seasoning experiments, however, were taken in July. The data concerning temperature, precipitation, wind velocity, etc., during the entire period of seasoning, May, 1905, to November, 1906, are embodied in Table 1.

TABLE 1.—*Meteorological conditions in northern Michigan.*

Month.	Average monthly temperature.			Average monthly precipitation.			Average hourly wind velocity.				Number of clear days.	
	1905.	1906.	Average 33 years.	1905.	1906.	Average 33 years.	1905.		1906.		1905.	1906.
							Miles.	Direction.	Miles.	Direction.		
	° *F.*	° *F.*	° *F.*	*Inch.*	*Inch.*	*Inch.*						
March	25.1	19.8	24.0	2.64	2.84	1.93	6.3	S	10.2	N	8	13
April	37.3	41.4	37.2	2.00	1.51	2.02	7.3	N	9.6	S	9	13
May	47.3	47.4	49.3	3.07	1.67	3.47	8.0	NE	10.9	S	13	6
June	58.6	61.2	60.7	5.21	2.85	3.69	7.1	S	8.0	S	14	13
July	63.7	65.4	66.6	4.39	2.02	3.39	6.6	S	8.0	S	12	19
August	65.2	67.4	64.6	1.84	3.11	3.60	6.0	S	9.0	NE	14	13
September	59.0	61.1	57.0	2.21	3.49	3.59	7.1	S	9.5	S	14	13
October	44.0	45.7	45.7	3.19	2.95	3.24	8.3	NW	10.2	S	11	9
November	33.4	35.0	32.2	2.49	4.85	2.11	8.5	NW	10.3	SW	3	4
December	25.8	.....	21.7	1.63	.....	1.67	7.1	SW	.....	.....	7	.....
January	23.6	.....	15.4	3.42	.....	1.55	8.3	SW	.....	.....	7	.....
February	16.6	.....	15.1	.71	.....	1.41	11.1	SW	.....	.....	8	.....

From Table 1 it is apparent that during the late spring and early summer of 1905 the temperature was slightly lower than the average, and during the late summer and early fall slightly higher. During the spring and early summer of 1906 the temperature was normal, but during late summer and fall higher than the average. In the spring of 1905 the rainfall was about normal; during June and July it exceeded the average; August and September were comparatively dry; and from then on to the end of the year normal conditions were restored. During 1906 the rainfall was far below the average, except in the fall. In 1905 the wind velocity was much less than in 1906. In both years the wind was most active during May, October, and November, January, and February. Snow fell from October, 1905, to April, 1906, inclusive. The largest number of clear days occurred from May to October, inclusive, 1905, and from June to September, 1906.

In addition to the better situation of the poles, the meteorological conditions during the spring of 1906 were much more favorable for seasoning than in the preceding year.

EFFECT OF THE FACTORS INFLUENCING SEASONING.

LOSS OF MOISTURE.

In working up the seasoning data from these experiments the actual volumes of each 5-foot section were used, but an endeavor was made to ascertain if a shorter method, avoiding the necessity of tak-

ing these sectional measurements, might not prove practicable for computing the volume of 30-foot arborvitæ poles. For white cedar (*Chamæcyparis thyoides*), it has been determined that the approximate volume can be obtained by multiplying the area of the cross section at the balancing point by the length of the pole.[a] The accuracy of this method for arborvitæ poles was tested with the result shown in Table 2.

TABLE 2.—*Average volume of poles.*

Cut—	Skidway number.	By 5-foot circumferences.	By balancing point.	Difference.	Basis.
		Cu. ft.	*Cu. ft.*	*Cu. ft.*	*Poles.*
April 22	I	19.65	20.91	1.26	25
Do	II	17.93	18.65	.72	25
May 20	III	17.09	18.06	.97	25
Do	IV	18.13	19.58	1.45	25
June 24	V	17.16	17.77	.61	25
Do	VI	16.79	17.45	.66	25
July 22	VII	16.15	16.84	.69	25
Do	VIII	16.52	17.17	.65	25
August 20	IX	17.89	18.94	1.05	25
Do	X	18.17	19.10	.93	25
September 25	XI	18.63	19.29	.66	25
Do	XII	18.97	19.08	.11	25
October 25	XIII	18.01	19.06	1.05	25
Do	XIV	17.64	17.89	.25	25
November 20	XV	17.36	17.55	.19	25
Do	XVI	16.62	17.05	.43	25
December 19	XVII	16.89	17.09	.20	22
Do	XVIII	16.99	17.42	.43	25
Average, 447 poles				.68	

The natural expectation would be that, on account of the large percentage of hollow butts found in arborvitæ, the balancing point would be nearer the top than in the case of solid poles, and consequently the volume by this method would be too small. It will be seen from Table 2, however, that the volume in every case is too great, the excess averaging about 0.68 cubic foot per pole. This variation is so small that the method could be used to good advantage with 30-foot poles.

The first weights of the poles of each cut were averaged and the results considered the green weight of the timber. These varied considerably on account of individual variations in the poles, the season of cutting, and the different meteorological conditions to which the poles were exposed. Eliminating the weight variations whose peculiarities could be accounted for, it was found that the winter-cut poles had a slightly greater weight per cubic foot than those cut in spring and summer. The average green weight for all seasons was approximately 32 pounds, the maximum 34.2 pounds, and the minimum 30.7 pounds. (Fig. 2.)

[a] In weighing poles by means of the apparatus described, it is a simple matter to determine the balancing point. A plumb bob is attached to the lower hook of the scale and allowed to drop to a point close to the pole. When the pole is properly balanced the plumb bob will hang directly above the balancing point, which can be permanently marked with a painted line.

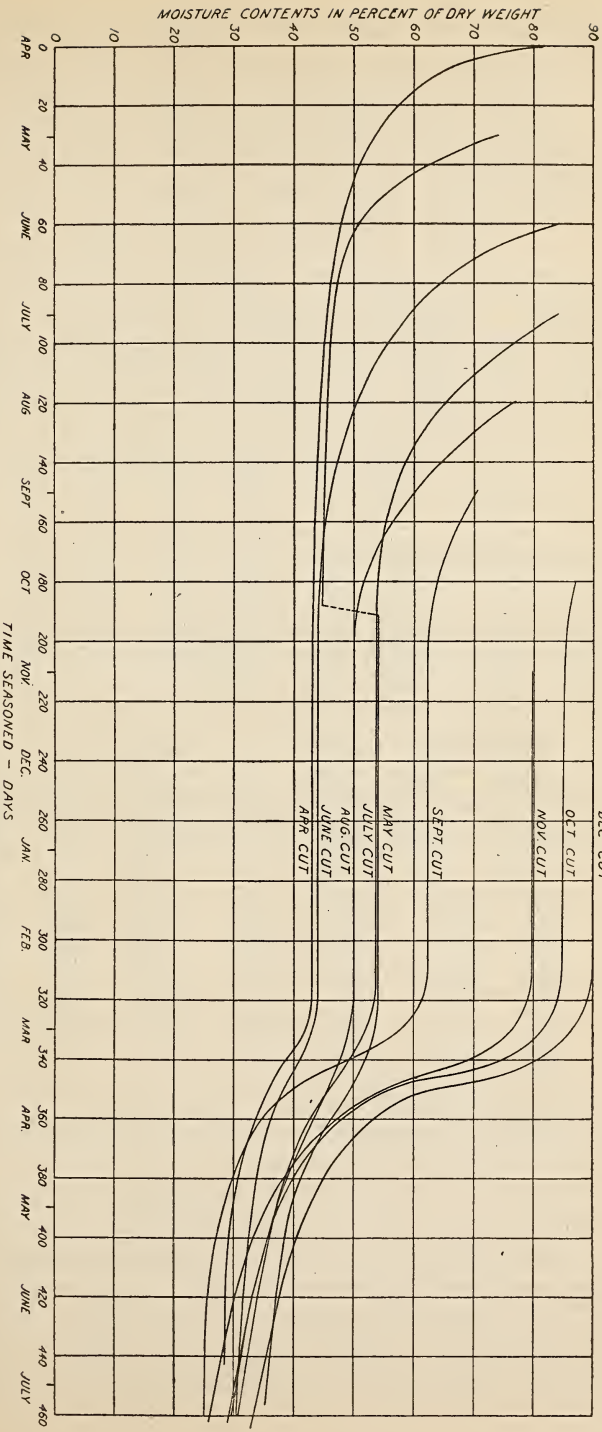

FIG. 2.—Diagram showing relation of moisture content to seasoning time.

The dry weight was found to be 18 pounds per cubic foot. This was determined by drying small sections of a large number of poles in an oven at 100° C. until a constant weight was attained.

At each weighing period the average weight per cubic foot and the average moisture content in per cent of dry weight were computed for each monthly cut.

TABLE 3.—*Weight and moisture content.*

Time seasoned.	April cut.		May cut.		June cut.		July cut.		August cut.	
	Moisture content in relation to dry weight.	Weight per cubic foot.	Moisture content in relation to dry weight.	Weight per cubic foot.	Moisture content in relation to dry weight.	Weight per cubic foot.	Moisture content in relation to dry weight.	Weight per cubic foot.	Moisture content in relation to dry weight.	Weight per cubic foot.
Days.	*Per cent.*	*Lbs.*	*Per cent.*	*Lbs.*	*Per cent.*	*Lbs.*	*Per cent.*	*Lbs.*	*Per cent.*	*Lbs.*
0	81.3	32.6	74.0	31.3	84.0	33.1	84.2	33.2	76.7	31.8
30	53.7	27.7	50.9	27.2	59.3	28.7	65.1	29.7	60.0	28.8
60	47.8	26.6	46.5	26.4	50.3	27.1	56.5	28.2	51.6	27.3
90	45.5	26.2	45.6	26.2	46.0	26.3	54.0	27.7	49.9	27.0
120	44.3	26.0	45.0	26.1	44.2	26.0	53.7	27.7	49.9	27.0
150	43.7	25.9	44.8	26.1	44.0	25.9	53.7	27.7	49.9	27.0
180	43.2	25.8	54.0	27.7	44.0	25.9	53.7	27.7	49.9	27.0
210	43.0	25.7	54.0	27.7	44.0	25.9	53.6	27.6	49.0	26.8
240	43.0	25.7	53.9	27.7	44.0	25.9	51.8	27.3	43.2	25.8
270	43.0	25.7	53.9	27.7	43.0	25.7	42.7	25.7	37.0	24.7
300	43.0	25.7	53.4	27.6	36.2	24.5	37.0	24.7	33.0	23.9
330	42.0	25.6	46.3	26.3	33.0	23.9	33.9	24.1	30.0	23.4
360	33.5	24.0	39.5	25.1	31.6	23.7	31.4	23.7	.....	.....
390	29.7	23.3	37.0	24.7	30.6	23.5	.....	.....	.....	.....
420	28.5	23.1	35.5	24.4	.....	.....	.....	.....	.....	.....
450	28.5	23.1	.....	.....	.....	.....	.....	.....	.....	.....

Time seasoned.	September cut.		October cut.		November cut.		December cut.	
	Moisture content in relation to dry weight.	Weight per cubic foot.	Moisture content in relation to dry weight.	Weight per cubic foot.	Moisture content in relation to dry weight.	Weight per cubic foot.	Moisture content in relation to dry weight.	Weight per cubic foot.
Days.	*Per cent.*	*Lbs.*	*Per cent.*	*Lbs.*	*Per cent.*	*Lbs.*	*Per cent.*	*Lbs.*
0	70.3	30.7	87.0	33.7	79.7	32.3	90.0	34.2
30	63.9	29.5	85.0	33.3	79.7	32.3	90.0	34.2
60	62.3	29.2	85.0	33.3	79.7	32.3	90.0	34.2
90	62.3	29.2	85.0	33.3	79.7	32.3	86.4	33.6
120	62.3	29.2	84.9	33.3	76.3	31.7	58.0	27.5
150	62.3	29.2	81.5	32.7	47.0	26.5	42.3	25.6
180	57.9	28.4	48.0	26.6	35.1	24.3	37.5	24.8
210	34.8	24.3	37.4	24.7	30.0	23.4	34.3	24.2
240	28.3	23.1	33.0	23.9	26.9	22.8	.....	.....
270	25.7	22.6	30.4	23.5	.....	.....	.....	.....
300	25.0	22.5	.....	.....	.....	.....	.....	.....

Oven-dry weight = 18 pounds per cubic foot. Green moisture content, per cent: Average, 80.8; maximum, 90; minimum, 70.3. Dry moisture content, per cent: Average, 30.3; maximum, 35.5; minimum, 25.

From Table 3 it is evident that seasoning is very rapid in the spring, and stands still from about the middle of October until the middle of March. The more favorable conditions during the spring of 1906 are evident from the very rapid rate at which seasoning took place, even in the poles which were cut in the preceding spring. The rapid increase in weight shown by the May-cut poles after about 180 days' seasoning is accounted for by the fact that it rained

heavily just before the poles were weighed. This increase of moisture was not lost until the following spring, because of continuous freezing weather throughout the winter. The lowest weight was 22.5 pounds per cubic foot, attained by the September-cut poles after 300 days' seasoning. This is probably very close to the air-dry weight. When the weighings were discontinued the fall and winter cut poles were losing moisture much more rapidly than those cut in spring and summer.

The uniform behavior of poles cut during the same season of the year led to combining them into seasonal groups. April and May were taken as spring; June, July, and August as summer; September, October, and November as autumn. December was the only winter month represented. The months are thus grouped in seasons in Table 4, which shows the original weight and progress of seasoning of poles cut at different times of the year.

TABLE 4.—*Weight and moisture content by seasonal cuts.*

Time seasoned.	Spring cut.		Summer cut.		Autumn cut.		Winter cut.	
	Moisture content in relation to dry weight.	Weight per cubic foot.	Moisture content in relation to dry weight.	Weight per cubic foot.	Moisture content in relation to dry weight.	Weight per cubic foot.	Moisture content in relation to dry weight.	Weight per cubic foot.
Days.	*Per cent.*	*Pounds.*	*Per cent.*	*Pounds.*	*Per cent.*	*Pounds.*	*Per cent.*	*Pounds.*
0	77.4	31.9	81.7	32.7	79.0	32.2	90.0	34.2
30	53.8	27.7	61.4	29.1	79.0	32.2	90.0	34.2
60	49.7	26.9	51.9	27.3	79.0	32.2	90.0	34.2
90	48.4	26.7	49.1	26.8	79.0	32.2	86.4	33.6
120	48.3	26.7	49.0	26.8	79.0	32.2	53.0	27.5
150	48.3	26.7	49.0	26.8	77.2	31.9	42.3	25.6
180	48.3	26.7	49.0	26.8	43.0	25.7	37.5	24.8
210	48.3	26.7	49.0	26.8	33.2	24.0	34.3	24.2
240	48.3	26.7	48.0	26.6	29.0	23.2	.....	.....
270	48.3	26.7	40.5	25.3	27.2	22.9	.....	.....
300	48.3	26.7	35.7	24.4	.....	.....	.....	.....
330	44.2	26.0	32.9	23.9	.....	.....	.....	.....
360	36.0	24.5	30.7	23.5	.....	.....	.....	.....
390	33.7	24.1	.....	.....	.....	.....	.....	.....
420	32.3	23.8	.....	.....	.....	.....	.....	.....

Oven-dry weight = 18 pounds per cubic foot.

The spring and summer cuts start to season rapidly. This rate continues for about 60 days, then decreases slowly until at the end of 90 days it stops until the following spring. Then the poles begin to lose moisture again at a fairly rapid rate, which continues until 390 and 360 days, respectively, are passed. After that the seasoning is very slow. (Fig. 3.)

The autumn poles start with a slightly lower moisture content than do the summer-cut poles, and practically no moisture is lost until spring. The rate of seasoning then becomes very rapid, and during the summer a much lower moisture content is attained than that of the spring and summer poles. The autumn-cut poles reached

in 210 days the same degree of seasoning that the spring poles reached in 390 days.

The winter poles start with by far the greatest moisture content, and no seasoning takes place until about the middle of March. Then throughout the spring months the loss of moisture is very rapid, but it steadily decreases during the summer, the greater part of the moisture being lost in 160 days.

Fall and winter cut poles, then, attain the maximum degree of seasoning in the shortest time: of the two seasons winter is somewhat preferable. Winter-cut poles will reach about the same moisture content in 220 days that the spring and summer cuts attain in about 400 and 320 days, respectively. Moreover, in the winter months the cutting and hauling of the timbers are greatly facilitated by the frozen condition of the ground.

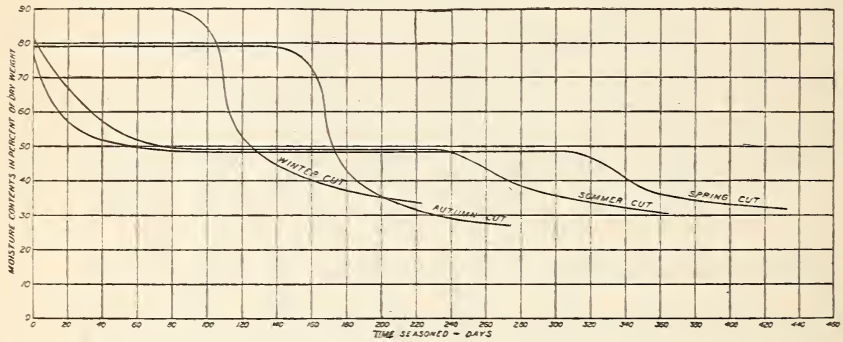

FIG. 3.—Diagram showing moisture content in relation to seasoning time—seasonal cutting.

One of the most important reasons for seasoning poles, aside from the gain in strength and durability, is the saving on freight charges. Table 5 shows the weight per cent saved on poles cut at various times in the year and seasoned for varying periods. It is assumed that seasoning takes place under conditions similar to those encountered in the experiment.

TABLE 5.—*Per cent of freight weight saved by seasoning.*

Time seasoned.	Spring cut.	Summer cut.	Autumn cut.	Winter cut.	Time seasoned.	Spring cut.	Summer cut.	Autumn cut.	Winter cut.
Days.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Days.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
30	13.2	11.0	.....	.....	240	16.3	18.7	28.0	.....
60	15.7	16.5	.....	.....	270	16.3	22.6	28.9	.....
90	16.3	18.0	.....	1.8	300	16.3	25.4	.....	.....
120	16.3	18.0	.....	19.6	330	18.5	26.9	.....	.....
150	16.3	18.0	0.9	25.1	360	23.2	28.1	.....	.....
180	16.3	18.0	20.2	27.5	390	24.5	.....	.....	.....
210	16.3	18.0	25.5	29.2	420	25.4	.....	.....	.....

From the same data Table 6 has been deduced, showing the most advantageous shipping time for poles cut at different seasons, the

weight which they should reach, their moisture per cent, and the per cent of freight weight saved.

TABLE 6.—*Relative economy of various cutting seasons and shipping times.*

Cut.	Ship after—	Weight per cubic foot.	Moisture.	Freight saved.
	Months.	*Pounds.*	*Per cent.*	*Per cent.*
Spring	2	26.9	49.7	15.7
Summer	2	27.3	51.9	16.5
Autumn	6	26.8	43.0	20.2
Winter	4	27.5	53.0	19.6

These shipping periods are set with reference to the average of the cutting period; that is, an autumn-cut pole if held until the following May would save 20.2 per cent on freight charges. The saving

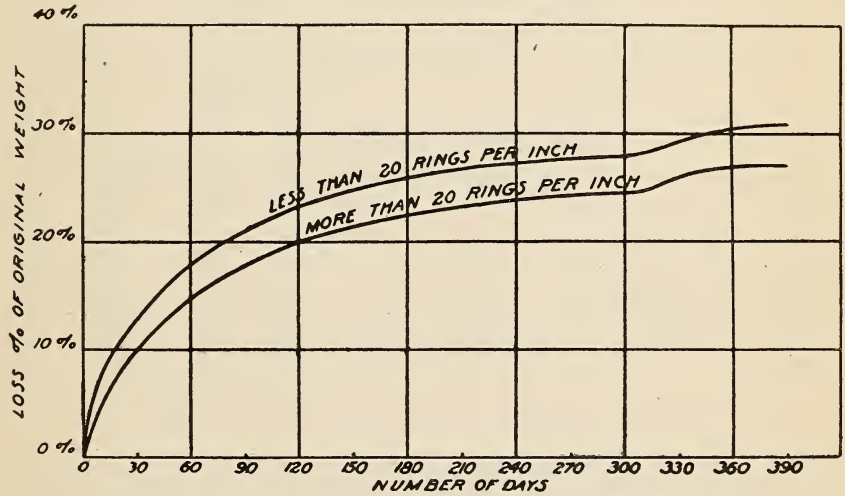

FIG. 4.—Diagram showing effect of rate of growth upon seasoning.

on a car of seasoned poles will be considerable, especially if shipped to distant points.

The effect of rate of growth upon seasoning is shown by the curves in figure 4. The sapwood alone has been considered. From these curves it is apparent that poles having less than 20 annual rings per inch in the sapwood season nearly 4 per cent faster than those of slower growth.

The effect of hollow butts upon the rate of seasoning is shown by the curves in figure 5. These curves show that poles having hollow butts, in which the decayed portion is 4 inches or over in diameter, season about 8.5 per cent faster than those having solid butts. (Fig. 5.)

SHRINKAGE.

The sapwood zone of an arborvitæ pole is narrow at the butt and gradually widens as the top is approached. Because of this proportionately greater amount of sapwood at the top, the seasoning is most rapid in that portion of the pole, with a consequently greater shrinkage. However, the top stops shrinking before the butt, as its supply of water capable of being evaporated is sooner exhausted.

The shrinkage of 450 poles between the time when the poles were absolutely green and after about sixteen and a half months' seasoning is shown in Table 7.

TABLE 7.—*Pole shrinkage.*

Skid (25 poles).	Average circumference.			
	Green.		Seasoned.	
	6 feet.	30 feet.	6 feet.	30 feet.
	Inches.	*Inches.*	*Inches.*	*Inches.*
I	38.9	24.5	38.66	24.20
II	37.1	23.4	36.87	23.18
III	36.0	23.2	35.94	22.99
IV	37.4	23.4	37.25	23.20
V	36.6	23.6	35.87	23.45
VI	35.7	23.5	35.54	23.34
VII	34.8	23.6	34.88	23.54
VIII	35.0	23.7	34.84	23.46
IX	37.1	24.2	36.97	23.99
X	37.0	24.1	36.89	23.93
XI	37.6	24.7	37.37	24.52
XII	37.4	25.7	37.20	25.51
XIII	37.4	24.9	37.04	24.52
XIV	36.3	24.3	35.86	23.87
XV	36.2	23.9	35.81	23.60
XVI	35.4	23.6	35.18	23.26
XVII	35.3	22.9	35.22	22.81
XVIII	35.1	22.9	35.01	22.80
Average	36.42	23.89	36.24	23.67

The total average shrinkage of the poles at 6 feet above the butt was found to be 0.18 inch, or 0.49 per cent of the average green circumference, and at the top, 0.22 inch, or 0.92 per cent of the circumference at that point. This amount is so small that it is negligible for all practical purposes. For this reason, it was not deemed necessary to separate the poles into diameter or age classes. Probably all shrinkage occurs within a few months after cutting, and after that the circumference is dependent upon weather conditions, damp days swelling the poles nearly or quite to their green size, and subsequent dry weather reducing them again.

CHECKING.

Under the conditions met with in the experiments, seasoning progressed at a relatively slow rate, and the consequent checking caused no practical damage. The checks which did occur were about one-

fourth to one-half inch deep on an average and from one to several feet long. Because of the more rapid initial seasoning of the spring and summer cut poles, they developed larger and more numerous checks than the poles cut in the fall and winter.

ACTION OF FUNGI AND INSECTS.

In situations where skidded poles are exposed for a long period to conditions of relatively high humidity and temperature the attacks of fungi and insects must be taken into consideration. Under the conditions met with in the seasoning experiments at Escanaba, however, these factors were of no importance.

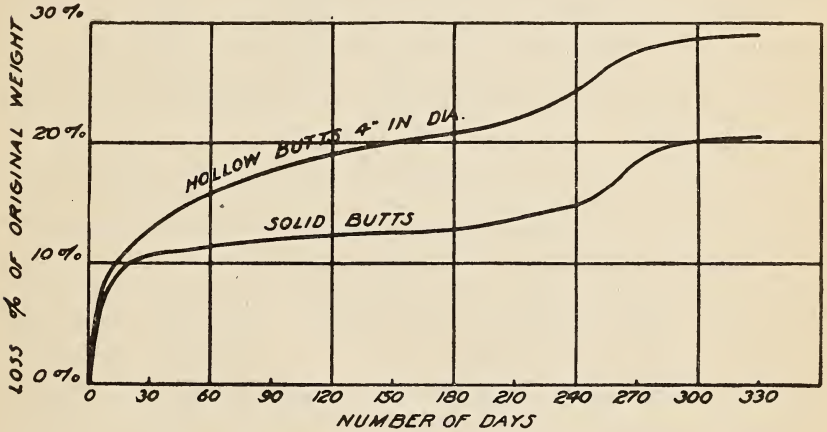

FIG. 5.—Diagram showing effect of hollow butts upon rate of seasoning.

FORM, AGE, AND CONDITION OF ARBORVITÆ POLES.

The average taper of a 30-foot pole was computed from circumference measurements made on 447 green poles, and is as follows:

Rate of Taper.

Circumference at—	Inches.	Circumference at—	Inches.
Butt	43.4	15 feet	31.7
5 feet	37.2	20 feet	29.2
6 feet	36.4	25 feet	26.7
10 feet	34.1	30 feet	23.9

Average green weight, 574 pounds.
Average circumference at balancing point, 32.8 inches.
Average length from butt to balancing point, 12.5 feet.
Average volume, 17.62 cubic feet.

The table shows that the taper from the butt to the 30-foot point is 6.21 inches, an average of about 1 inch in 5 feet. From the butt to the 5-foot point the taper is 2 inches; from the 5 to the 10-foot

point. 1 inch: from 10 to 15. 0.76 inch: from 15 to 20. 0.79 inch: from 20 to 25. 0.79 inch: from 25 to 30. 0.90 inch. The taper is most rapid near the butt: from the 5-foot point it gradually decreases until the 15-foot point is reached, when it again increases toward the top.

The circumference at the balancing point, as determined by balancing 447 poles, was found to be 32.8 inches, situated at an average distance of 12.5 feet from the butt. Only one determination was made when the poles were green. Ordinarily, loss of moisture being more rapid near the top, the balancing point would move slightly toward the butt as seasoning progressed. But on account of the large proportion of hollow butts, it was decided that this might remain stationary or even move slightly toward the top. At any rate, the movement was so slight that the original determination was a sufficient guide for setting the skidding tongs for subsequent weighings.

The average time it takes to produce a 30-foot arborvitæ pole is about one hundred and ninety years. This was determined by a count on 114 poles. The large percentage of defective butts made it impossible to obtain the ages of all of the poles.

The butts of 274 poles, or over 50 per cent, contained defects more than 1 inch in diameter. In addition, many butts were pecky and had small crescent-shaped patches of rot. Small holes were frequently found in the tops also. As a rule the butt rot extended into the pole only a few feet and did not detract from its strength after setting. Although the percentage of butt rot appears large, it is probably a fair average for the region. A few poles had "cat faces," or old wounds, partially overgrown, leaving a long, narrow, dead surface exposed, but in no case were these large enough to cause serious injury.

PRESERVATIVE TREATMENT.

Preservative treatments, both by brush and open-tank methods, were begun in November, 1906, and extended through the following month. The extreme northern location of Escanaba intensified somewhat the inconveniences always to be met in winter treating operations. These were encountered chiefly in the brush treatments. The low temperature of the atmosphere and of the timber cooled the preservative and obstructed the penetration. The oil in the first coating, moreover, formed an almost impenetrable film over the timber, which was melted with difficulty when the second coat was applied. In the open tanks, on the other hand, the more rapid cooling of the oil, after the fires were extinguished, may have assisted the penetration somewhat.

The final seasoning weights were taken in July, 1906, and the treating experiments were begun in the following November. In the meantime the poles had been exposed to frequent rainfall and as a consequence their moisture content had considerably increased. Nearly 200 poles were weighed immediately before treatment. These weights showed that the poles had increased 1.42 pounds per cubic foot since the preceding July, and 2.52 pounds more than the lowest weight attained by any month's cut during the seasoning period. Hence any satisfactory results from the various methods could have been obtained as well with a shorter period of seasoning.

Besides the 446 seasoned poles, 43 green ones were later secured from near Munising, Mich. In addition, 3 tamarack poles, seasoned in the yard for two years, were treated in the open tank.

Of the 492 poles included in the experiment, 199, of which 156 were seasoned and 43 green, were treated by the open-tank creosote process. Ninety-eight were given a 2-coat carbolineum brush treatment,[a] the same number were treated with 2 coats of creosote, and the remaining 98 were left untreated as a basis for comparison.

All the poles were plainly marked to indicate the month in which they were cut, thus 4/18, to indicate the eighteenth pole of the April allotment. The tamarack poles were simply numbered 1, 2, and 3. The green poles were designated by placing the letter "G" above the individual number.

Each of the monthly cuts was apportioned for the various treatments, as follows:

	Numbers.
Carbolineum brush treatment	1–11
Creosote brush treatment	12–22
Creosote open-tank treatment	23–39
Seasoned untreated (12/43 missing)	40–50

All tamarack and green arborvitæ poles were tank-treated.

CARBOLINEUM BY THE BRUSH METHOD.

Ninety-eight poles were given a 2-coat brush application of carbolineum. Treatments were begun November 3 and continued until November 12. The thin inner bark which was left in patches on the winter-cut poles when they were peeled in the woods was removed very carefully, for it was found that even a light, thin strip prevented the oil from penetrating the wood.

The first treatments were made when the weather was very mild, but it became considerably colder while the last ones were being put on. This thickened the oil of the second coat as it touched the cold

[a] One of these was later discarded on account of a broken top.

timber and interfered with the penetration. The difference in the consistency of carbolineum, however, as affected by temperature, is not nearly so marked as with creosote. All defects and season checks on the treated portion of the pole were given a very thorough application. The carbolineum was heated in a large iron kettle, the oil being maintained at about 220° F.

A record was kept for each individual pole, covering the amount of oil in pounds used in each application, the average temperature of the oil during treatment, and the date of application.

The oil was applied for a distance of 6 feet, beginning 2 feet from the butt. As much oil was applied as the timber would absorb. No second coats were applied within twenty-four hours of the first, and the oil was re-heated for each application.

The amount of oil absorbed in the first coat varied from 1.25 to 3.75 pounds per pole, with an average of 2.39 pounds. The second coats required considerably less, ranging from 0.5 to 2.5 pounds per pole, with an average of 1.55 pounds. The combined coats varied between 2 and 7 pounds limits, giving an average of 3.93 pounds for the series. Individual variations may be accounted for by such factors as the size of the butt, the degree of checking, the amount of defect of surface, and weather conditions. The average penetration did not exceed one-sixteenth of an inch.

COST OF TREATMENT.[a]

As a conservative estimate, one fairly efficient laborer can apply five first coats or six second coats per hour. Allowing $1.75 per man for an 8-hour day and figuring the weight of carbolineum at 8½ pounds per gallon and its cost at 80 cents, the following figures are derived for the cost per pole:

	First coat.	Second coat.
Labor	$0.044	$0.036
Carbolineum (2.39 pounds)	.225	[a] .146
	.269	.182
Both coats	.451	

[a] 1.55 pounds.

In estimating the cost of labor it is assumed that the poles are skidded in a single layer well off the ground. The necessity of carefully pealing the butts of winter-cut poles makes an added expense which would probably be slight in commercial operations.

[a] In estimating the costs of the treatments figures are based upon the actual conditions encountered at Escanaba during the experiment. They would not apply to treatments on a commercial scale nor to experiments at any other station.

CREOSOTE BY THE BRUSH METHOD.

The creosote brush treatments were begun November 14 and continued until November 20. In all, 2-coat applications were given to 98 seasoned poles. The winter-cut poles were shaved as with the carbolineum treatments.

Most of the oil used was taken from the open tanks, which were in operation close by. Initial temperatures ranged from 200° to 210° F. During the painting the temperature of the oil would drop from 30° to 40° on an average, depending upon the quantity of oil in the pail and atmospheric conditions.

Records covering the same data as in the foregoing treatments were kept, and the same method of application was followed. As with the carbolineum treatments, cold weather prevents the creosote from penetrating the wood as well as it would under more favorable conditions. However, it is probable that some of the preservative which adheres to the surface when applied in cold weather will soak into the wood in the spring.

Absorption varied from 1.5 to 4.5 pounds per pole for the first coat, with an average for the 98 poles of 2.95 pounds; and from 0.65 pound to 2.5 pounds for the second coat, an average of 1.45 pounds. The average absorption per pole, including both coatings, was 4.4 pounds, nearly one-half pound more than in the case of carbolineum.

COST OF TREATMENT.

Where the first cost of the preservative is high, it is the principal factor in determining the total cost of the treatments. With creosote, however, costing only from 8 to 10 cents per gallon, the expense is greatly reduced.

Assuming the same value for labor, as before, a similar weight per gallon for creosote as for carbolineum, and a similar condition of the poles as in the carbolineum treatments, we get the following figures:

	First coat.	Second coat.
Labor	$0.044	$0.036
Creosote (2.95 lbs.) at 8 cents per gallon	.027	[a].014
	.071	.050
Both coats	.121	

[a] 1.45 pounds.

It is probable that if the work is done during the summer the absorption of oil will be heavier, with a consequent increase in cost.

Assuming the life of an untreated pole to be 12 years, its cost $9 set in the line, the rate of interest on the investment 6 per cent, the cost of the carbolineum brush treatment 45 cents, and of a creosote brush treatment 16 cents (estimated cost for summer treatments), it is found that the carbolineum brush treatments would have to add about one year to the life of the pole, and creosote but one-third of a year, to pay for the cost of treatment.[a]

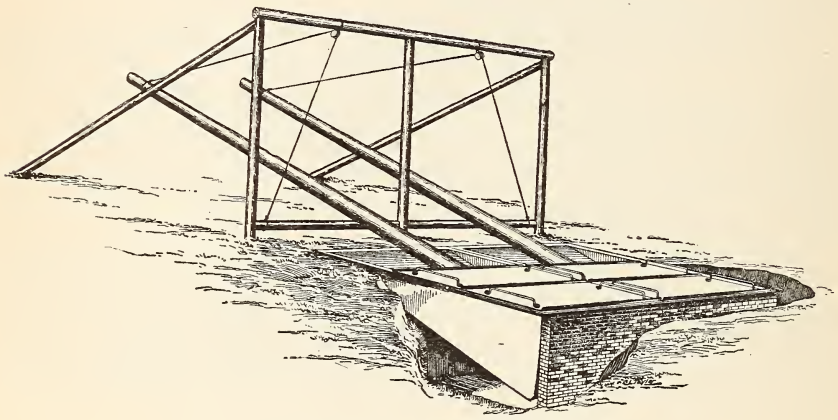

FIG. 6.—Open tank for treating telephone poles.

The chief advantages of brush treatments lie in the economy of first cost and the simplicity of operation. In the case of green timber, experiments have proved that brush treatments with ordinary preservatives are a failure. Whether such treatments will stand the test of relative economy when applied to seasoned timber remains to be determined by actual trial.

In view of the fact that arborvitæ is an exceptionally valuable pole timber, and that prices will probably continue to rise as rapidly or even more rapidly than they have in the past few years, it is important that the most thorough method of preservation should be adopted, provided that the cost of treatment does not exceed the gain from the increased life of the pole.

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[a] To secure the basis for this comparison of the annual charges of brush-treated and untreated poles, the following formula was used: $r = R\,\frac{1.Op^n Op}{1.Op^n - 1}$, in which r = annual charge, R = initial expenditure, p = rate of interest, n = years in the recurring period and $1.Op = \frac{100+p}{100}$.

CREOSOTE BY THE OPEN-TANK METHOD [a]

For the open-tank treatments creosote alone was employed. Exact data were sought on the maximum possible penetration, the length of the treatment in both hot and cold baths giving the most satisfactory results, and the condition of the timber necessary to secure them.

The treating outfit consisted of two large sheet-iron tanks, each big enough for four poles with the butts immersed 7 feet in the oil. (Fig. 6.)

Wood fires were started under the tanks early in the morning, so that the poles of the previous day's run could be removed from the oil which had hardened over night, and the new poles immersed between 9 and 10 a. m. The treated poles were then dragged directly to skids, which were placed at a convenient distance from the tanks.

For each pole a record was kept of its weight before and after treatment, the absorption, the temperature of the oil at frequent intervals during treatment, and, in the case of a large number of the poles, of the resulting penetration. All borings made to ascertain the penetration were subsequently closed with creosoted wooden plugs.

The duration of the treatment was computed from the time the oil reached 212° F. until the fires were drawn. In most of the treatments the temperature was maintained as near 220° F. as possible. In all cases, at the conclusion of the hot-oil treatment, the poles were allowed to remain in the oil until it attained an atmospheric temperature.

It was found that better results are secured by a steady increase in temperature until the desired heat is attained than by allowing it to fluctuate. Steam coils are therefore more satisfactory than an open fire.

About 13 barrels of oil were required to charge each tank. During cold weather the oil tends to solidify, and it is necessary to break in the barrels. Where steam is available, however, for forcing into the bungholes, this may be obviated, and the barrels saved for further use.

The oil used in the treatments was received in two shipments of 50 and 10 barrels, respectively. The oils in both shipments, however, although they varied in color from light yellow to black, were found to be of similar composition. The creosote was analyzed at the beginning of the work and again after 36 treatments, in order to determine the effect of continuous heating upon its composition.

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[a] Forest Service Circulars 101, The Open-Tank Method for the Treatment of Timber, and 104, Brush and Tank Pole Treatments, deal with this subject.

From the records, the amount of oil absorbed by the timber and used in other ways was 37 barrels. Adding to this amount the quantity of oil remaining after the treatments were concluded, and subtracting the result from the whole quantity of oil, it is found that 38.3 per cent can be accounted for only on the supposition that it volatilized during the experiments.

The comparison of the analyses made at the beginning of treatments and after thirty-six days' use are shown in figure 7.

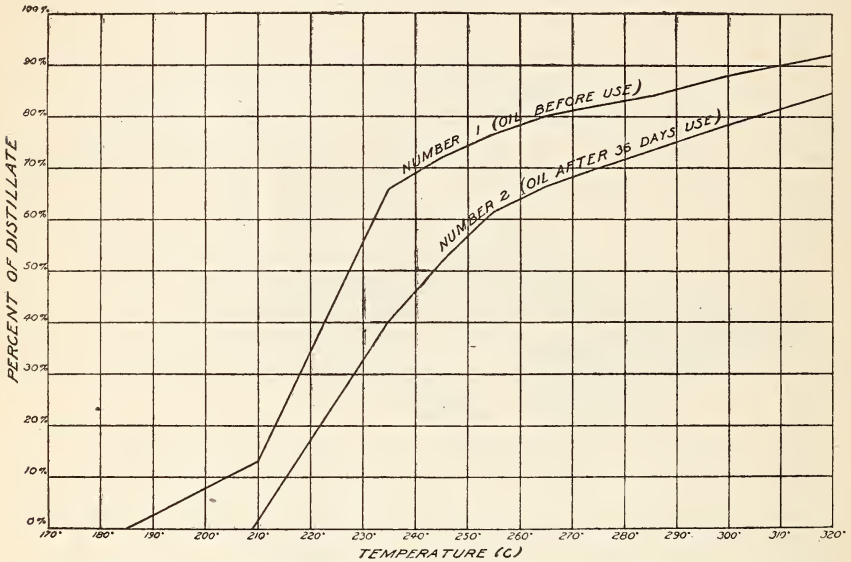

FIG. 7.—Diagram showing comparative composition of creosote before and after its successive use in open-tank treatments.

The percentage of loss, according to the analyses,[a] was 41.2. The volatilization as determined by this accurate method, then, does not differ greatly from the previously estimated loss. In treating timber, the difference in vaporization between fresh and old oils is plainly evident to the eye. The dense clouds of naphthalene and other light oils given off from the surface of the tanks at the beginning of the treatments gradually decreased during the course of the

[a] If we assume that there has been practically no loss in the fractions distilling above 245° C., we find the following relation:

$$\frac{\text{Per cent of oil No. 2 distilling above 245° C.}}{\text{Per cent of oil No. 1 distilling above 245° C.}} = \frac{47.4}{28.0} = 1.7;$$

that is, 1.7 gallons of the original oil are required to yield 1 gallon of the oil remaining after the treatments were concluded. The percentage loss is therefore $\frac{7}{17} = 41.2$.

Forest Circular 80, Fractional Distillation of Coal-Tar Creosote, contains information along this general line.

experiment. The form of these experimental tanks is such as to give a maximum oil surface and a minimum timber capacity, which resulted in an extreme lack of economy. For this reason the volatilization during the course of the experiments was much greater than need occur under proper commercial conditions.

TREATMENT OF SEASONED ARBORVITÆ POLES.

The seasoned arborvitæ poles absorbed from 30 to 90 pounds of oil each, with an average of 48.4 pounds per pole. The individual absorptions varied between wide limits, according to the thickness of the sapwood, the width of its annual rings, and the defects of the butt.

FACTORS THAT DETERMINE ABSORPTION.

Absorptions are so strongly influenced by the varying factors that it is hard to correlate any two of them. Table 8, which was designed primarily to show the relation between absorption, duration of treatment, and cutting season, includes also the important factors of rapidity of growth and condition of the timber as to butt defects.

The runs were grouped, according to the duration of treatment, into series ranging from three to twelve hours. About 70 per cent of the poles were allowed to remain from six to eight hours in hot oil.

TABLE 8.—*Average absorption per pole.*

Month cut.	Rings in last inch.	Poles with butt rot.	Length of treatment in hot oil (hours).							Average.	
			3.	4.	5.	6.[a]	7.	8.	12.	Length of treatment.	Absorption.
		Per ct.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Hours.*	*Lbs.*
April	24	94.2	.....	58^{1}	.....	.....	60^{16}	.....	.....	6.8	59.9^{17}
May	34	94.2	.....	70^{5}	.....	67^{12}	.....	.....	.....	5.4	67.9^{17}
June	35	47.1	.....	44^{8}	.....	57^{9}	.....	.....	.....	5.1	50.9^{17}
July	33	47.1	.....	.....	33^{5}	46^{12}	.....	.....	.....	5.7	42.2^{17}
August	37	70.6	.....	.....	.....	36^{8}	48^{9}	.....	.....	6.5	42.4^{17}
September	28	35.3	.....	44^{2}	.....	36^{6}	.....	46^{1}	42^{8}	8.7	40.4^{17}
October	31	58.8	45^{4}	34^{4}	28^{2}	35^{4}	51^{3}	.....	.....	4.9	48.1^{17}
November	32	82.4	.....	.....	.....	48^{13}	.....	55^{3}	.....	6.4	49.3^{16}
December	30	70.6	.....	.....	24^{3}	48^{11}	51^{3}	.....	.....	6.0	44.3^{17}
Average	31.6	66.7	45^{4}	49^{20}	29^{10}	49^{75}	51^{31}	53^{4}	42^{8}	6.2	49.5^{159}

The smaller figures indicate number of poles used in the average.

[a] It had been shown from previous experiments on other timbers that a 6-hour immersion in hot oil was probably the most efficacious. Consequently a large proportion of the poles were subjected to this treatment.

The 3 and 4 hour runs compare very favorably with the 6-hour treatments. The 7 and 8 hour treatments show a slightly higher average of absorption than the 6-hour, while the 12-hour run of September poles shows a decided falling off in comparison with the other averages.

The question of the relation of cutting season to absorption is so intimately bound up with the amount of defective wood in the butt

that it is best to consider the three in connection. Grouping and averaging the data from the treatment sheets into seasons of cutting, the comparative series given in Table 9 is obtained:

TABLE 9.—*Average absorption, by season cuts.*

	Per cent of poles with hollow butt.	Average absorption, all treatments.
		Pounds.
Spring-cut (April and May)	94.2	64.0^{34}
Summer-cut (June, July, August)	54.9	45.0^{51}
Fall-cut (September, October, November)	58.8	43.0^{50}
Winter-cut (December)	70.6	44.0^{17}

The smaller figures denote the number of poles used in the average.

The spring-cut poles show the greatest absorption and at the same time have the greatest number of specimens with defective butts. The summer, winter, and fall cut poles follow next in order with regard to the quantity of oil absorbed. It may be that the absorption of the winter poles exceeded that of the fall poles because they had the greater proportion of defective butts, not only in number, but also with regard to the average size of the individual rot.

Table 10 shows the effect which unsound butts exert on the absorption of the oil, assuming the average length of treatment to be the same for sound and unsound poles.

TABLE 10.—*Effect of unsound butts upon absorption.*

Month cut.	Average absorption sound butts.	Average absorption unsound butts.	Difference.	Per cent unsound.	Average diameter of rot.	Average.
	Pounds.	*Pounds.*	*Pounds.*		*Inches.*	
April	52.0^{1}	60.6^{16}	8.6	94.2	2.59	2.54
May	62.0^{1}	68.4^{16}	6.4	94.2	2.50	
June	47.4^{9}	54.3^{8}	6.9	47.1	2.69	
July[a]						2.60
August	38.0^{5}	44.5^{12}	6.5	70.6	2.50	
September	36.1^{11}	48.3^{6}	12.2	35.3	1.94	
October	32.6^{7}	43.6^{10}	11.0	58.8	2.43	2.67
November	35.7^{3}	56.9^{14}	21.2	82.4	3.63	
December	28.8^{5}	50.5^{12}	21.7	70.6	2.73	2.73
Average	41.6^{42}	52.7^{94}	11.1	69.1		

The smaller figures denote the number of poles used in the average.

[a] Because of certain variations shown in the July poles it was impossible to include them in the table.

It is seen that the average difference in absorption between sound and unsound poles for the spring and summer cuts varies between 6 and 8 pounds. With the fall and winter cut poles the difference is greater—between 11 and 22 pounds. This is partially explained by the fact that the diameter of the defect in the butts in the spring and

summer poles averaged 2.57 inches, while in the fall and winter poles it averaged 2.7 inches. Including the poles cut during all seasons of the year, the average difference in absorption between those having sound and unsound butts amounts to 11.1 pounds per pole. This partially accounts for the variation in absorption shown in Table 10.

Reducing the absorptions to a still more general average, it is found that where 51 to 100 per cent of the poles have hollow butts the average absorption is 50.4 pounds, and where only 50 per cent or less are affected the average absorption is reduced to 44.5 pounds.

The degree of penetration furnishes a much more direct and accurate way for determining the relative efficiency of the treatments, since the highly variable factor of butt rot is thus eliminated. The average penetration for 89 poles was approximately 0.5 inch, varying between 0.2 and 1 inch.

The sapwood of arborvitæ is only one-half to 1 inch thick, and it was found that it constituted the most important factor in determining the penetration of the oil. The fibrous inner bark adhering to the winter-cut poles was not removed, as it was from the brush-treated poles, and it must have reduced the penetration, though to a slighter degree than in the brush treatments.

RELATION BETWEEN RATE OF GROWTH AND PENETRATION.

The number of rings in the outermost inch on the cross sections of the butts, based on counts made on 88 poles, was found to average 31. A direct relation apparently exists between the rate of growth and the penetration. Inasmuch as the faster-growing trees, with the wider annual rings, have a correspondingly thicker sapwood, the penetration is directly affected, since a complete penetration of the sapwood is secured in both cases. The heartwood is seldom penetrated to a considerable extent.

TABLE 11.—*Effect of rate of growth upon penetration.*

	Penetrations between 0.2 and 0.5 inch.[a]	Penetrations between 0.51 and 1 inch.[b]
Average number rings	32.90	27.70
Average penetration.....inch..	.40	.73

[a] 63 poles. [b] 25 poles.

In Table 11 the average number of rings and the average penetration for 63 poles, the penetration of which varied between 0.2 and 0.5 inch, is compared with the same data computed from 25 poles, with penetrations between 0.51 and 1 inch.

TABLE 12.—*Comparison of penetrations for each month's cut.*

Month cut.	Average number rings, outer inch.	Average penetration.	Average penetration (by seasonal cuts).
		Inch.	*Inch.*
April	23	0.69^{9}	0.57
May	33	$.46^{11}$	
June	35	$.55^{10}$	
July	35	$.60^{10}$	.54
August	33	$.49^{8}$	
September	28	$.36^{9}$	
October	81	$.41^{14}$	.40
November	32	$.43^{8}$	
December	32	$.41^{10}$	.41

The smaller figures denote the number of poles used in the average.

It is seen from Table 12 that spring and summer cut poles are apparently more easily penetrated. The average difference in penetration between these and the fall and winter cut poles combined is 0.15 inch.

To show the true relation between absorption, penetration, and width of annual rings, another computation was made with only sound poles as a basis, using in each case as many records of penetration as were available. All monthly allotments were represented. Four groups were made, based on the number of rings in the last inch. Since all butt-rot defects were eliminated, the figures offer a fairly reliable comparison.

TABLE 13.—*Effect of rate of growth upon penetration and absorption (sound poles only).*

Number rings to last inch.	Average absorption.	Average penetration.
	Pounds.	*Inch.*
10–20	46^{9}	$.58^{3}$
21–30	44^{14}	$.49^{5}$
31–40	39^{13}	$.40^{5}$
41–60	37^{9}	$.39^{6}$

The smaller figures denote the number of poles used in the average.

The series given in Table 13 tends to confirm the theory that the more rapidly grown poles absorb the preservative more readily. Thus poles with 10 to 20 rings in the last inch absorb 25 per cent more oil and gain 50 per cent more in penetration than poles with 41 to 60 rings.

COST OF TREATMENT.

The expenses of treating poles may be grouped into three main classes—labor, oil, and fuel.

Basing the amount of oil required on the absorption of the seasoned poles and estimating the fuel at one-third cord of hardwood per day, the following figures are derived:

Cost of treating 8 poles.

1 man and team 1½ hours, at 50 cents	$0.75
1 extra man 1½ hours, at 20 cents	.30
1 regular man all day, at $1.75	1.75
Creosote, 83.7 gallons, at 8 cents	6.70
Fuel, one-third cord hardwood, at $5	1.66
Total	11.16
Cost per pole	1.40

This makes the estimated cost of treatment $1.40 per pole. The cost of the oil itself, estimated at 8 cents per gallon, is 83.7 cents per pole. This is rather high as compared with previous estimates, because of conditions inducing excessive volatilization.

On the basis of an annual charge, using as the basic data the estimated life of a seasoned pole as 12 years, of a treated pole 20 years, and an interest rate of 6 per cent, the following figures are derived:

	Annual charge.
Untreated pole, life 12 years (cost $9 set in the line)	$1.07
Treated pole, life 20 years (cost $10.39 set in the line)	.91

Such a cost will be justified if the treatment adds three years to the life of the pole.

TREATMENT OF GREEN ARBORVITÆ POLES.

The 43 green poles were treated in the open tank by a method similar to that used for the seasoned poles. They were frozen when they reached the treating tanks, and dried in streaks.

The absorption during treatment was variable. About 25 per cent of the poles lost 2 to 18 pounds in weight. The remaining poles gained from 4 to 18 pounds, with an average of 12.5 for 33 poles. The butts of 63 per cent were defective.

The average penetration for all green poles was 0.25 inch, the maximum in one case reaching as high as 0.75 inch, while the minimum in several cases was 0.1 inch. In several cases the oil formed only a thin coating which could have no more preservative effect than a brush application. Often a pole showed a penetration of only 0.1 inch on one side, while the other recorded as high as 0.5 inch. This irregularity was attributed to variations in the moisture content of the wood and the frozen condition of the poles. In a few cases where patches of thin bark still adhered to the poles no penetration whatever was secured.

Six, eight, and twelve hour runs were tried, but each showed extreme irregularity in its individual penetrations. Better results, however, were secured with the longer treatments; but on the whole the green-pole treatments can not be considered a success.

TREATMENT OF SEASONED TAMARACK POLES.

The tamarack poles had been seasoned for about two years, and were very dry and considerably checked. The butts were from 8 to 10 inches in diameter and sound. The average absorption of oil was 25 pounds, and the average penetration 0.25 inch for a 6-hour treatment. The penetration was assisted to a certain extent by the season checks.

The results secured were satisfactory, and it is possible that by this method the local consumption of tamarack as a pole timber may be largely increased.

CONCLUSIONS.

SEASONING.

(1) Green arborvitæ poles lose the larger portion of their moisture from the sapwood. This is very thin, consequently loss begins immediately after exposure to favorable seasoning influences, and a large per cent of the moisture is lost during sixty days of fair weather. Spring and early summer offer the best conditions for maximum seasoning in the shortest time.

(2) Poles cut and peeled during late fall and winter and skidded in a single layer well off the ground should be held until the first of May before shipping, thus insuring a decrease in freight weight more than equal to the expense of holding. Poles so held will also gain in strength and durability.

(3) Late fall and winter offer the best conditions for cutting, skidding, and hauling, and these operations should be carried on at that time.

(4) The amount of shrinkage during seasoning is too small to be taken into account.

(5) Checking during seasoning has no particular effect on the strength of the pole and is of little assistance in the absorption of the oil. Checking is greatest in the spring and summer cut poles.

TREATING.

(1) If arborvitæ poles are properly seasoned the sapwood can be thoroughly impregnated with creosote in the open tank.

(2) Fall and winter cut poles should be in satisfactory condition for impregnation by the following June if skidded according to the plan followed in the experiment. If skidded several layers deep, as is the usual custom, they will probably have to be seasoned for a longer period.

(3) With seasoned poles the sapwood can be thoroughly impregnated by a hot-oil open-tank treatment of 3 to 7 hours between 212° and 220° F. Probably the 3-hour period is as efficacious as the

7-hour, the differences in the experimental treatments being due to variations in the amount of sapwood and not to the duration of the bath.

(4) After the immersion in hot oil a bath in the cold preservative is necessary. Unless the oil is changed at the conclusion of the hot bath the fires should be drawn and the poles allowed to remain in the oil until it has approached atmospheric temperature.

(5) Green arborvitæ poles show great variation in open-tank treatment. Penetration is neither deep nor uniform and is not sufficient to justify the treatment for this class of material.

(6) Brush treatments of green poles can not be justified.

(7) The penetration on brush-treated seasoned poles is slight. The value of this method of treatment can be determined only by experience.

(8) Seasoned tamarack poles show fairly deep and uniform penetration of the oil when treated in the open tank. Further experiments with this timber are desirable.

CONSTRUCTION OF EXPERIMENTAL LINE.

In selecting a locality for setting the poles a region will be secured in which normal conditions are represented. The poles will be placed so as to include varying sites and exposures.

The poles will be set in such a manner that each contrasting series will be under practically the same conditions. The following scheme will be followed:

(1) Tank treated.
(2) Carbolineum brush treated.
(3) Tank treated.
(4) Creosote brush treated.
(5) Seasoned, untreated.
(1) Tank treated, etc.

The three tamarack poles will be included in the line.

The 489 arborvitæ poles will form a continuous line 12.2 miles long, 40 poles per mile.

Approved:

JAMES WILSON, *Secretary.*

WASHINGTON, *D. C., November 16, 1907.*

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